

CLAIMS

- 1 1. For executing in a plurality of threads of execution a garbage collector that col-
2 lects in increments, in each of which the garbage collector collects a respective collection
3 set associated with that increment and consisting of a set of at least one collection-set sec-
4 tion for which the garbage collector has maintained a respective remembered set, associ-
5 ated with that collection-set section, that lists locations where references to objects in the
6 respective collection-set section have been found, the garbage collector collecting the col-
7 lection set by employing the threads to search the locations listed by each such remem-
8 bered set for references outside the collection set to objects in the collection set and
9 evacuating from the collection set objects thereby referred to, at least some such objects
10 being thereby evacuated in a first, normal-object-evacuation manner, a method wherein:
11 A) when any of the threads searches the locations listed by one of the remem-
12 bered sets, that thread maintains for the collection-set section with which
13 that remembered set is associated a count map that includes, for each of a
14 plurality of section segments into which the thread treats that collection-
15 set section as divided, a count-map entry, associated with that section
16 segment, that contains a count value of how many references to an object
17 in the section segment associated with that count-map entry that thread has
18 found; and
19 B) the garbage collector evacuates, in a second, popular-object-evacuation
20 manner, different from the normal-object evacuation manner, each object
21 located in a section segment whose count value meets a popular-object cri-
22 terion.
- 1 2. A method as defined by claim 1 wherein each evacuation performed in a popular-
2 object-evacuation manner includes placing the object thereby evacuated in a section ex-
3 clusively occupied by that object.

1 3. A method as defined by claim 1 wherein the garbage collector imposes a mini-
2 mum object size and no section segment's size is greater than the minimum object size.

1 4. A method as defined by claim 1 wherein:

- 2 A) the garbage collector in some increments employs more than one of the
3 threads to search for references to objects in the same collection-set sec-
4 tion; and
5 B) the count map that each such thread maintains for that collection-set sec-
6 tion is separate from the count map maintained by each other such thread
7 for that collection-set section.

1 5. A method as defined by claim 4 wherein, when a thread searching for references
2 to objects in one or more of the collection-set sections finds such a reference, it:

- 3 A) increments the value contained in the count-map entry associated with the
4 section segment where the object thereby referred to is located;
5 B) makes a determination of whether that value has reached an individual-
6 map popular-object threshold; and
7 C) if the determination is affirmative, evacuates that object in the popular-
8 object-evacuation manner.

1 6. A method as defined by claim 5 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
3 different threads maintain for the same section segment;
4 B) makes a determination of whether that value has reached a multiple-map
5 popular-object threshold; and
6 C) if the determination is affirmative, evacuates that object in a popular-
7 object-evacuation manner.

1 7. A method as defined by claim 6 wherein the individual- map popular-object
2 threshold equals the multiple-map popular-object threshold.

1 8. A method as defined by claim 4 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
- 3 different threads maintain for the same section segment;
- 4 B) makes a determination of whether that value has reached a multiple-map
- 5 popular-object threshold; and
- 6 C) if the determination is affirmative, evacuates that object in a popular-
- 7 object-evacuation manner.

1 9. A method as defined by claim 4 wherein each evacuation performed in a popular-
2 object-evacuation manner includes placing the object thereby evacuated in a section ex-
3 clusively occupied by that object.

1 10. A method as defined by claim 4 wherein the garbage collector imposes a mini-
2 mum object size and no section segment's size is greater than the minimum object size.

1 11. A computer system configured by machine instructions to execute in a plurality of
2 threads a garbage collector that collects in increments, in each of which the garbage col-
3 lector collects a respective collection set associated with that increment and consisting of
4 a set of at least one collection-set section for which the garbage collector has maintained
5 a respective remembered set, associated with that collection-set section, that lists loca-
6 tions where references to objects in the respective collection-set section have been found,
7 the garbage collector collecting the collection set by employing the threads to search the
8 locations listed by each such remembered set for references outside the collection set to
9 objects in the collection set and evacuating from the collection set objects thereby re-
10 ferred to, at least some such objects being thereby evacuated in a first, normal-object-

11 evacuation manner, the computer system being so configured by the machine instructions
12 that:

- 13 A) when any of the threads searches the locations listed by one of the remem-
14 bered sets, that thread maintains for the collection-set section with which
15 that remembered set is associated a count map that includes, for each of a
16 plurality of section segments into which the thread treats that collection-
17 set section as divided, a count-map entry, associated with that section
18 segment, that contains a count value of how many references to an object
19 in the segment associated with that count-map entry that thread has found;
20 and
21 B) the garbage collector evacuates, in a second, popular-object-evacuation
22 manner, different from the normal-object evacuation manner, each object
23 located in a section segment whose count value meets a popular-object cri-
24 terion.

1 12. A computer system as defined by claim 11 wherein each evacuation performed in
2 a popular-object-evacuation manner includes placing the object thereby evacuated in a
3 section exclusively occupied by that object.

1 13. A computer system as defined by claim 11 wherein the garbage collector imposes
2 a minimum object size and no section segment's size is greater than the minimum object
3 size.

1 14. A computer system as defined by claim 11 wherein:

- 2 A) the garbage collector in some increments employs more than one of the
3 threads to search for references to objects in the same collection-set sec-
4 tion; and

- 5 B) the count map that each such thread maintains for that collection-set sec-
6 tion is separate from the count map maintained by each other such thread
7 for that collection-set section.

1 15. A computer system as defined by claim 14 wherein, when a thread searching for
2 references to objects in one or more of the collection-set sections finds such a reference,
3 it:

- 4 A) increments the value contained in the count-map entry associated with the
5 section segment where the object thereby referred to is located;
6 B) makes a determination of whether that value has reached an individual-
7 map popular-object threshold; and
8 C) if the determination is affirmative, evacuates that object in the popular-
9 object-evacuation manner.

1 16. A computer system as defined by claim 15 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
3 different threads maintain for the same section segment;
4 B) makes a determination of whether that value has reached a multiple-map
5 popular-object threshold; and
6 C) if the determination is affirmative, evacuates that object in a popular-
7 object-evacuation manner.

1 17. A computer system as defined by claim 16 wherein the individual- map popular-
2 object threshold equals the multiple-map popular-object threshold.

1 18. A computer system as defined by claim 14 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
3 different threads maintain for the same section segment;

- 4 B) makes a determination of whether that value has reached a multiple-map
- 5 popular-object threshold; and
- 6 C) if the determination is affirmative, evacuates that object in a popular-
- 7 object-evacuation manner.

1 19. A computer system as defined by claim 14 wherein each evacuation performed in
2 a popular-object-evacuation manner includes placing the object thereby evacuated in a
3 section exclusively occupied by that object.

1 20. A computer system as defined by claim 14 wherein the garbage collector imposes
2 a minimum object size and no section segment's size is greater than the minimum object
3 size.

1 21. A storage medium containing instructions readable by a computer system to con- ✓
2 figure the computer system to execute in a plurality of threads a garbage collector that
3 collects in increments, in each of which the garbage collector collects a respective collec-
4 tion set associated with that increment and consisting of a set of at least one collection-set
5 section for which the garbage collector has maintained a respective remembered set, as-
6 sociated with that collection-set section, that lists locations where references to objects in
7 the respective collection-set section have been found, the garbage collector collecting the
8 collection set by employing the threads to search the locations listed by each such re-
9 membered set for references outside the collection set to objects in the collection set and
10 evacuating from the collection set objects thereby referred to, at least some such objects
11 being thereby evacuated in a first, normal-object-evacuation manner, the computer sys-
12 tem being so configured by the machine instructions that:

- 13 A) when any of the threads searches the locations listed by one of the remem-
- 14 bered sets, that thread maintains for the collection-set section with which
- 15 that remembered set is associated a count map that includes, for each of a
- 16 plurality of section segments into which the thread treats that collection-

17 set section as divided, a count-map entry, associated with that section
18 segment, that contains a count value of how many references to an object
19 in the segment associated with that count-map entry that thread has found;
20 and
21 B) the garbage collector evacuates, in a second, popular-object-evacuation
22 manner, different from the normal-object evacuation manner, each object
23 located in a section segment whose count value meets a popular-object cri-
24 terion.

1 22. A storage medium as defined by claim 21 wherein each evacuation performed in a
2 popular-object-evacuation manner includes placing the object thereby evacuated in a sec-
3 tion exclusively occupied by that object.

1 23. A storage medium as defined by claim 21 wherein the garbage collector imposes
2 a minimum object size and no section segment's size is greater than the minimum object
3 size.

1 24. A storage medium as defined by claim 21 wherein:

- 2 A) the garbage collector in some increments employs more than one of the
3 threads to search for references to objects in the same collection-set sec-
4 tion; and
5 B) the count map that each such thread maintains for that collection-set sec-
6 tion is separate from the count map maintained by each other such thread
7 for that collection-set section.

1 25. A storage medium as defined by claim 24 wherein, when a thread searching for
2 references to objects in one or more of the collection-set sections finds such a reference,
3 it:

- 4 A) increments the value contained in the count-map entry associated with the
5 section segment where the object thereby referred to is located;
- 6 B) makes a determination of whether that value has reached an individual-
7 map popular-object threshold; and
- 8 C) if the determination is affirmative, evacuates that object in the popular-
9 object-evacuation manner.

1 26. A storage medium as defined by claim 25 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
3 different threads maintain for the same section segment;
- 4 B) makes a determination of whether that value has reached a multiple-map
5 popular-object threshold; and
- 6 C) if the determination is affirmative, evacuates that object in a popular-
7 object-evacuation manner.

1 27. A storage medium as defined by claim 26 wherein the individual- map popular-
2 object threshold equals the multiple-map popular-object threshold.

1 28. A storage medium as defined by claim 24 wherein the collector additionally:

- 2 A) computes the sum of the values contained in the count-map entries that
3 different threads maintain for the same section segment;
- 4 B) makes a determination of whether that value has reached a multiple-map
5 popular-object threshold; and
- 6 C) if the determination is affirmative, evacuates that object in a popular-
7 object-evacuation manner.

1 29. A storage medium as defined by claim 24 wherein each evacuation performed in a
2 popular-object-evacuation manner includes placing the object thereby evacuated in a sec-
3 tion exclusively occupied by that object.

1 30. A storage medium as defined by claim 24 wherein the garbage collector imposes
2 a minimum object size and no section segment's size is greater than the minimum object
3 size.

1 31. An electromagnetic signal representing instructions readable by a computer sys-
2 tem to configure the computer system to execute in a plurality of threads a garbage col-
3 lector that collects in increments, in each of which the garbage collector collects a respec-
4 tive collection set associated with that increment and consisting of a set of at least one
5 collection-set section for which the garbage collector has maintained a respective re-
6 membered set, associated with that collection-set section, that lists locations where refer-
7 ences to objects in the respective collection-set section have been found, the garbage col-
8 lector collecting the collection set by employing the threads to search the locations listed
9 by each such remembered set for references outside the collection set to objects in the
10 collection set and evacuating from the collection set objects thereby referred to, at least
11 some such objects being thereby evacuated in a first, normal-object-evacuation manner,
12 the computer system being so configured by the machine instructions that:

13 A) when any of the threads searches the locations listed by one of the remem-
14 bered sets, that thread maintains for the collection-set section with which
15 that remembered set is associated a count map that includes, for each of a
16 plurality of section segments into which the thread treats that collection-
17 set section as divided, a count-map entry, associated with that section
18 segment, that contains a count value of how many references to an object
19 in the segment associated with that count-map entry that thread has found;
20 and

21 B) the garbage collector evacuates, in a second, popular-object-evacuation
22 manner, different from the normal-object evacuation manner, each object
23 located in a section segment whose count value meets a popular-object cri-
24 terion.

1 32. An electromagnetic signal as defined by claim 31 wherein each evacuation per-
2 formed in a popular-object-evacuation manner includes placing the object thereby evacu-
3 ated in a section exclusively occupied by that object.

1 33. An electromagnetic signal as defined by claim 31 wherein the garbage collector
2 imposes a minimum object size and no section segment's size is greater than the mini-
3 mum object size.

1 34. An electromagnetic signal as defined by claim 31 wherein:

- 2 A) the garbage collector in some increments employs more than one of the
3 threads to search for references to objects in the same collection-set sec-
4 tion; and
5 B) the count map that each such thread maintains for that collection-set sec-
6 tion is separate from the count map maintained by each other such thread
7 for that collection-set section.

1 35. An electromagnetic signal as defined by claim 34 wherein, when a thread search-
2 ing for references to objects in one or more of the collection-set sections finds such a ref-
3 erence, it:

- 4 A) increments the value contained in the count-map entry associated with the
5 section segment where the object thereby referred to is located;
6 B) makes a determination of whether that value has reached an individual-
7 map popular-object threshold; and

8 C) if the determination is affirmative, evacuates that object in the popular-
9 object-evacuation manner.

1 36. An electromagnetic signal as defined by claim 35 wherein the collector addition-
2 ally:

3 A) computes the sum of the values contained in the count-map entries that
4 different threads maintain for the same section segment;

5 B) makes a determination of whether that value has reached a multiple-map
6 popular-object threshold; and

7 C) if the determination is affirmative, evacuates that object in a popular-
8 object-evacuation manner.

1 37. An electromagnetic signal as defined by claim 36 wherein the individual- map
2 popular-object threshold equals the multiple-map popular-object threshold.

1 38. An electromagnetic signal as defined by claim 34 wherein the collector addition-
2 ally:

3 A) computes the sum of the values contained in the count-map entries that
4 different threads maintain for the same section segment;

5 B) makes a determination of whether that value has reached a multiple-map
6 popular-object threshold; and

7 C) if the determination is affirmative, evacuates that object in a popular-
8 object-evacuation manner.

1 39. An electromagnetic signal as defined by claim 34 wherein each evacuation per-
2 formed in a popular-object-evacuation manner includes placing the object thereby evacu-
3 ated in a section exclusively occupied by that object.

- 1 40. An electromagnetic signal as defined by claim 34 wherein the garbage collector
- 2 imposes a minimum object size and no section segment's size is greater than the mini-
- 3 mum object size.